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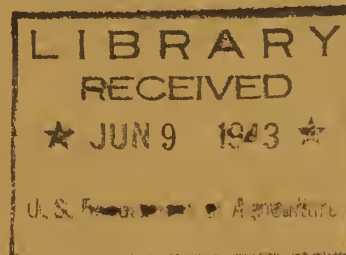
DIVISION OF FRUIT AND VEGETABLE CROPS AND DISEASES

H. T. & S. OFFICE REPORT NO. 53  
(DO NOT PUBLISH)

Title: Carbon Dioxide Shipping Tests with Georgia PEACHES - 1940

A Summarized Report of Investigations Conducted  
Author: in Cooperation with Shippers and Transportation  
Agencies

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Washington, D. C.

Date: Sept. 30, 1940



CARBON DIOXIDE SHIPPING TESTS WITH  
GEORGIA PEACHES - 1940

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These tests were undertaken as a part of the general investigation being made on the value of carbon dioxide gas treatments as a supplement to refrigeration in the shipment of fresh fruits and vegetables. The refrigerating effect of the dry ice used as a source of CO<sub>2</sub> gas was studied incidentally as there was opportunity.

Very adverse weather conditions were encountered during the course of the work, there being 18 consecutive rainy days during which it was usually impossible to obtain comparable shipments definitely consigned to the same market. The rainy weather also made the peaches more subject to decay and of poor shipping quality. The adverse weather conditions interfered most with the tests on the early varieties which often show greatest spoilage in transit and with which shippers are usually most willing to take additional precautions (such as CO<sub>2</sub> gas treatment or precooling) in order to insure safe delivery. The five best out of the seven tests conducted were with Elbertas, which will stand more abuse than any other variety and are frequently shipped to New York by truck with no refrigeration whatever.

Tests on Quantity of Dry Ice Needed

The first two tests, which, because of the rainy weather, were the only ones that could be conducted with the Hilcy variety,

failed to show any benefit from the CO<sub>2</sub> treatment given. However, the CO<sub>2</sub> treatment in those particular tests was based largely on recommendations currently given out by the company which supplied the dry ice; viz., that for truck shipments 100 pounds of dry ice on top of the water ice in the bunkers is all that is needed and that 300 pounds of dry ice on top of the water ice is sufficient for a refrigerator car. It was claimed that the use of this amount of dry ice makes it unnecessary to add salt to the ice in the bunkers of the car, so that the cost of the salt could be saved. The Department had conducted no previous experiments on the use of dry ice in truck shipments and had no direct information in regard thereto, but the recommendation relative to the quantity of dry ice in refrigerator cars was less than the earlier tests of the Department had indicated is advisable.

While one of the largest shipping organizations had already tried the treatments recommended and reported that they were not satisfactory, it appeared desirable to make official tests of those commercial recommendations. Accordingly, in one test 106 pounds of dry ice was added to the bunker of a truck and in another 511 pounds was added to the bunkers of a refrigerator car, with comparable nontreated check shipments forwarded at the same time. The gas analysis records taken in Georgia during the early part of the transit period indicated that in both tests, and especially in the truck shipment, the percentage of CO<sub>2</sub> was too low for any



decided effect upon decay, and, in both cases, the Department's New York representative reported slightly greater firmness but slightly more decay in the CO<sub>2</sub>-treated fruit.

In a later truck shipping test 450 pounds of dry ice was used and in later refrigerator-car tests 700 and 800 pounds were used. Because of diversions and delays in unloading in some of these tests it was not always possible to obtain direct comparisons of the gas-treated and the check fruit at destination, but the results as a whole gave evidence that these heavier gas treatments not only maintained firmness in the fruit but also in most cases definitely decreased decay, especially in the top layer of the refrigerator car where greatest spoilage is ordinarily found.

However, on the basis of these results it is not possible to draw conclusions as to whether or not it will pay a shipper to use gas treatments to supplement ordinary refrigeration. The most that can be said in this connection is that the tests definitely indicated that the limited quantities of dry ice called for by prevailing commercial recommendations are inadequate to accomplish any beneficial effect on the condition of the fruit, and do not give as good results as those obtained from the use of the larger quantities tested. The results of these tests did not prove that by use of dry ice it was possible to effect enough savings in other refrigerating costs to offset the cost of the dry ice under the conditions of these tests.

Tests on use of Dry Ice in Bunkers vs. in Loading Space

The commercial recommendation for the use of dry ice was to place it in the bunkers instead of over the load. The bunker application is the most convenient to make. In the first two tests with refrigerator cars, the dry ice was placed in the bunkers according to this recommendation. While the results were favorable when sufficient dry ice was used, it seemed advisable to compare the two methods of application, and this was done later in the two shipments from Woodland. The results show that the fruit in the top of the car was in far better condition both as to firmness and freedom from decay when the dry ice was placed over the load than when it was placed in the bunkers. It is likely that even better results could have been obtained if the dry ice had been placed some distance above the center of the load rather than in baskets resting on the load.

When dry ice is placed over the load the extremely cold  $\text{CO}_2$  makes its first contact with the fruit in the top of the load, where protection is needed most. When placed in the bunker much of its refrigerating effect is in cooling the ice (which can be done much more cheaply with salt), and the cold air and gas mixture reaches the fruit at the bottom bunker first, where protection is needed least. When dry ice is placed over the load, stratification of the carbon dioxide is prevented, whereas when placed in the bunker



the gas builds up from below, and the fruit in the top of the load gets the least protection.

That placing the dry ice in the bunker and accompanying it with heavy applications of salt may result in freezing at the bottom bunker is shown by the results of one of the tests made from Woodland. However, on the basis of the results of these limited tests a conclusion is not justified that salt is never needed when dry ice is used.

The satisfactory use of dry ice should be much simpler in trucks equipped with blowers. When dry ice is placed on top of the water ice in the bunker the blowers will carry the  $\text{CO}_2$  gas back over the load and give a more even distribution than is obtainable without the forced circulation.

#### Significance of Gas Leakage

Probably the most fundamental difficulty in obtaining satisfactory results from the use of the  $\text{CO}_2$  gas treatment in transit is the fact that neither trucks nor refrigerator cars approach gastightness. The two FDE cars used at Woodland were lined with plywood and were fairly tight, but there are very few cars of this type. The type of construction of the truck bodies should make them fairly tight, but the gaskets at the doors are often missing, some trucks have no drain-traps, and where traps have been installed they are often out of repair. These conditions are easily remedied

but it will take considerable education and pressure to cause operators to give adequate attention to them. Trucks appeared to require only about half as much dry ice as refrigerator cars to obtain a satisfactory percentage of gas, but this was probably largely due to the smaller air space left in the trucks after the load was in place since the fans must have increased the leakage of gas.

Dry ice has approximately twice the refrigerating capacity of water ice per unit of weight, but with water ice at \$5 a ton and dry ice at \$60, refrigeration by means of dry ice costs six times as much as refrigeration with water ice. From the standpoint of cost, therefore, it is impractical to use more dry ice than will give an adequate concentration of carbon dioxide gas. In this connection then it is evident that any increase in the tightness of cars and trucks will decrease the cost and increase the practicability of the carbon dioxide gas treatment.

#### Rail vs. Truck Shipment

There is intense competition between trucks and railroads for peach shipments out of Georgia. This should not be overlooked in plans for further tests. It was reported that trucks hauled more than one-third of the Georgia peach crop in 1939. In 1940 they started off with 50 or 60 percent of it, but when peaches

became oversoft because of the long-continued rainy weather, and the markets were glutted so that many diversions and delays were necessary, shippers were inclined to <sup>favor</sup> movement by rail in refrigerator cars.

The trucks offered a lower rate; their charge per half-bushel from Fort Valley to New York was 30 cents, whereas the refrigerator-car rate was 41 cents. The trucks saved handling at both ends of the line. They were ordinarily loaded at the orchard and delivered the fruit direct to the receiver, thus avoiding extra handling and transfer charges. While ordinarily the fans were kept in operation during loading, the bunkers were not usually iced until after loading was completed. The refrigerator cars were customarily preiced before loading, having about 5 tons of ice placed in the bunkers the night before loading, when they were sent out to the packing houses. Much of this ice had melted by the time loading was completed, and often comparatively little benefit was secured from it. The cost of this initial icing, with ice at \$5 per ton, was almost \$25, or approximately as much as the total refrigeration cost for the trucks.

There seemed to be poor usage of the man power and trucks in the trucking operations. Sometimes there were dozens of trucks waiting for a load with two idle men per truck. However, the trucks made better time to New York than was possible with rail shipments.

This was no advantage if they started in the afternoon, but if they started in the morning they made second- instead of third-morning delivery. As a result, peaches that were packed too late at night to get out by rail often were placed in iced refrigerator cars that were spotted at the packing house, and the next morning were reloaded into trucks so as to reach the market at the same time as the previous day's shipment. In such cases the truck shipments were given the benefit of refrigeration purchased from the railroads.

A brief summary of data, and observations on the various tests, are appended hereto.

COMPARISON OF SHIPMENT OF PEACHES BY TRUCK UNDER ORDINARY  
REFRIGERATION AND ORDINARY REFRIGERATION SUPPLEMENTED  
WITH 106 POUNDS OF DRY ICE

From Fort Valley, Ga., to New York, N. Y.,  
June 28 to July 1, 1940.

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This test with Hiley peaches was made in cooperation with the American Fruit Growers and Emmet Wilson, a truck broker.

The truck in which the dry ice was used was metal-covered followed by a course of 5-layer plywood, then about 2 inches of dry-zero, then by silver-seal paper, and an inside lining of 5-layer plywood. The check truck had the outside metal and

plywood layers but had Reynolds metallic insulation with an air space on each side instead of the dry-zero and silver-seal. Both trucks had gasoline motor-operated fans that drew the air up through the ice bunker in the front of the car and blew it back over the load. The dry-ice truck had a metal duct connected with the fan that carried the air back over the load and released it at well-distributed openings. The check truck did not have this duct. The truck bodies were 7 by 7.5 by 22 feet, giving 1,155 cubic feet of loading space.

The bunker capacity was 2,000 to 2,500 pounds. In a trip to New York 6 or 8 reicings are usually required, and the total cost of ice usually runs from \$20 to \$25. In this test the trucks were iced before being loaded, but in all later tests the icing was done after loading.

The check truck was loaded at Zenith and the dry-ice truck at Mossy Hill Farm, south of Perry. The loading was finished about 4:00 p.m., both trucks being loaded to the coiling. The check truck had 789 half-bushel baskets and the dry-ice truck 720. Three test baskets were placed in the top center of each car in the seventh layer and three in the bottom center, with a thermograph at each position. The trucks were brought back to Fort Valley for reicing, and 106 pounds of dry ice was placed in the test truck at about 4:45 p.m. The cost of the dry ice was \$3.18.



The fan failed to operate properly and was stopped about two-thirds of the time during the next hour and <sup>a</sup>half. Air samples were drawn at intervals from near the center of the truck. At 5:30 p.m. the air had 7 percent of CO<sub>2</sub> and at 6:15 p.m. 12 percent. The trucks were followed to Milledgeville, Ga., and at 9:00 p.m. the CO<sub>2</sub> concentration was 5.4 percent, and the dry ice was almost gone. The truck thermometer showed a temperature of 70° F. A leak was found at the bottom of the rear door that allowed a strong current of air to escape when the fans were operating.

The check truck was consigned to Heller Bros., 303 Washington Street, New York, N. Y., and the dry-ice truck to J. Nagler, 361 Washington Street, New York, N. Y.

The trucks were unloaded about 1:00 a.m., July 1. The temperatures of the fruit in the top of the load were lower than those in the bottom of the load. The thermograph records showed that the fruit in the dry-ice truck had cooled a little more rapidly than that in the check truck, but that may have been partly, if not largely due, to the overhead duct.

The average firmness of the fruit for the first 3 days after arrival, as determined by pressure tests, was: Dry ice truck, 14.0, 7.1, and 3.6 pounds; check truck, 13.2, 5.2, and 4.0 pounds, respectively.

The peaches from the check truck had slightly more color at the end of the first day, but this contrast disappeared by the end of the third day.

There was very little decay and no contrast in the decay from the two trucks during the first 3 days of holding. On the fifth day the peaches from the dry-ice truck had slightly more decay than those from the check. On the whole, the contrasts between the fruit in the two trucks were not great enough to be significant.

On the basis of earlier work the differences between the treatments given were not such that marked differences in the fruit should have been expected. In this test, however, the application of dry ice was limited to 106 pounds, because that was the recommendation of the local agency that supplied the dry ice. It was claimed that this amount was sufficient to eliminate several reicing stops.





TEMPERATURES IN TRANSIT IN TRUCKS  
WITH AND WITHOUT DRY ICE

TOP REAR

TRUCK-1-DRY ICE —  
TRUCK-2-CHECK - - - -

BOTTOM REAR

TRUCK-1-DRY ICE —  
TRUCK-2-CHECK - - - -

FORT VALLEY, GA.

FORT VALLEY, GA.

WASHINGTON, DC

WASHINGTON, DC

TRUCK-1-LOADED-FORT VALLEY, GA.  
TRUCK-1-INIT. ICED + 400 LBS DRY ICE  
TRUCK-2-LOADED-FORT VALLEY, GA.  
TRUCK-2-INIT. ICED

TRUCK-1-LOADED-FORT VALLEY, GA.  
TRUCK-1-INIT. ICED + 400 LBS DRY ICE  
TRUCK-2-LOADED-FORT VALLEY, GA.  
TRUCK-2-INIT. ICED

TRUCK-1-UNLOADED-WASHINGTON, DC  
TRUCK-2-UNLOADED-7-21-40-10:00PM. NEW YORK, N.Y.

TRUCK-1-UNLOADED-WASHINGTON, DC  
TRUCK-2-UNLOADED-7-21-40-10:00PM. NEW YORK, N.Y.

TRUCK-1-DRY ICE  
TRUCK-2-CHECK

TRUCK-1-DRY ICE  
TRUCK-2-CHECK

12 AM 7-18 12 PM 7-19 12 AM 7-20 12 PM 7-18 12 PM 7-19 12 AM 7-20

40° 45° 50° 55° 60° 65° 70° 75° 80° 85°







COMPARISON OF SHIPMENT OF PEACHES BY RAIL UNDER ORDINARY  
REFRIGERATION PLUS 3 PERCENT OF SALT IN  
FIRST TWO ICINGS AND ORDINARY  
REFRIGERATION PLUS  
511 POUNDS  
OF DRY ICE

From Fort Valley, Ga., to New York, N. Y.,  
July 9 to 11, 1940.

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The test was made with Hiley peaches from the Walter Pearson packing house, Fort Valley, Ga., July 9, 1940. The fruit was picked from the "2-inch-and-up" grading belt. Two different stages of maturity were selected: mature and fairly mature (called green). The pressure test of the mature ranged from 3 to 14.5 pounds and averaged 7.6 pounds; of the green from 7 to 14.5 pounds, averaging 12.0 pounds. The fruit temperature ranged from 80° to 83° F., averaging 81.6°. The weather was showery, and much of the fruit was smudgy because of being brushed when wet. Two half-bushel-basket test lots, one green and one mature, were placed at the top and bottom bunker and top and bottom doorway of each car. A Ryan thermograph was placed in a package of fruit at each position except the bottom doorway. WFE 67102 was closed at 2:30 p.m. and FGE 19317 at 4:00 p.m. At 4:20 p.m. 511 pounds of dry ice was added to the bunkers of the latter. At 6:20 p.m. the CO<sub>2</sub> in this car stood at 20.6 percent; at 9:00 p.m., at 21.5 percent. In Atlanta at 7:45 a.m. the following morning it had fallen to 7.3 percent. The first reicing was at Fort Valley at 9:30 p.m. and the second at Atlanta at

8:00 a.m. the next morning. The check car received 3 percent of salt at these first two loadings (3 percent of the ice added), whereas the car with dry ice added did not. The charge for the salt was \$7.00, and for the dry ice, \$15.33.

The thermograph records show that the fruit at the top bunker of the dry-ice car averaged about 4° warmer and the fruit at the top doorway about 5° warmer than that in the check car. Apparently the 3 percent of salt was considerably more effective than the 511 pounds of dry ice in lowering the temperature in the top of the car.

The following pressure tests taken in New York the first day after unloading show the relative condition of firmness of the fruit from different positions in the two cars.

	DRY-ICE CAR		CHECK CAR	
	Mature	Green	Mature	Green
	<u>Pounds</u>	<u>Pounds</u>	<u>Pounds</u>	<u>Pounds</u>
Top bunker-----	2.7	9.7	1.1	8.1
Bottom bunker-----	6.7	13.0	4.3	13.2
Top doorway-----	2.1	9.9	2.0	7.6
Bottom doorway-----	4.7	12.7	3.9	12.3
Average-----	4.1	11.3	2.8	10.2

The following records were obtained on brown rot:

Decay After Unloading

	DRY-ICE CAR		CONTROL CAR	
	Mature Percent	Green Percent	Mature Percent	Green Percent
First day:				
Top bunker-----	2.0	0	3.8	0.9
Bottom bunker-----	0	0	0	0
Top doorway-----	4.7	0	0.9	0
Bottom doorway-----	1.0	0	0	0
Second day:				
Top bunker-----	20.6	7.1	7.5	6.0
Bottom bunker-----	0	1.3	3.9	0
Top doorway-----	24.7	6.7	3.7	4.3
Bottom doorway-----	8.7	1.0	3.2	3.7
Third day:				
Top bunker-----	70.6	21.1	28.4	27.3
Bottom bunker-----	20.0	2.9	14.3	8.5
Top doorway-----	59.7	22.2	30.2	12.3
Bottom doorway-----	30.3	11.8	23.2	10.9

In the later inspections, 2 peaches affected with rhizopus rot were found in fruit from the dry-ice car and 1 in fruit from the check car.

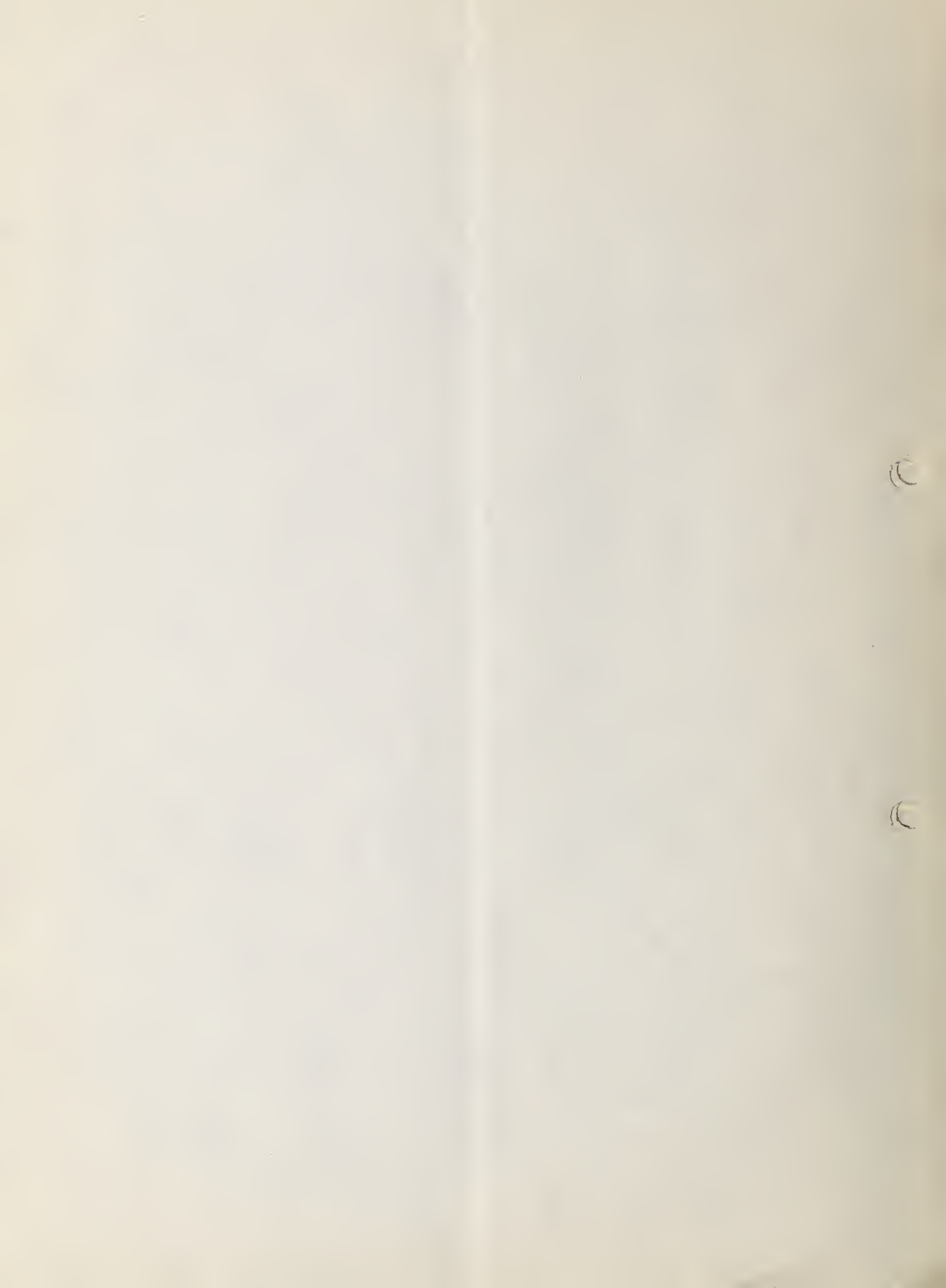
The fruit from the check car averaged softer than that from the dry-ice car, but there was more decay in the latter, probably due to the higher temperature in this car. The peaches in the top of the 2 cars showed about half as great pressure test and had more than twice as much decay as those in the bottom of the cars, probably due to the difference in temperature.

The peaches in the check car were sold for \$1 a basket and those in the gas-treated car for 90 cents a basket. The reason given by the receiver for the difference in price was that the peaches in the check car had better size. In this test the cost of the dry ice was not only not recovered, but the gas-treated peaches actually sold for less than the checks, although apparently not because of the gas treatment.

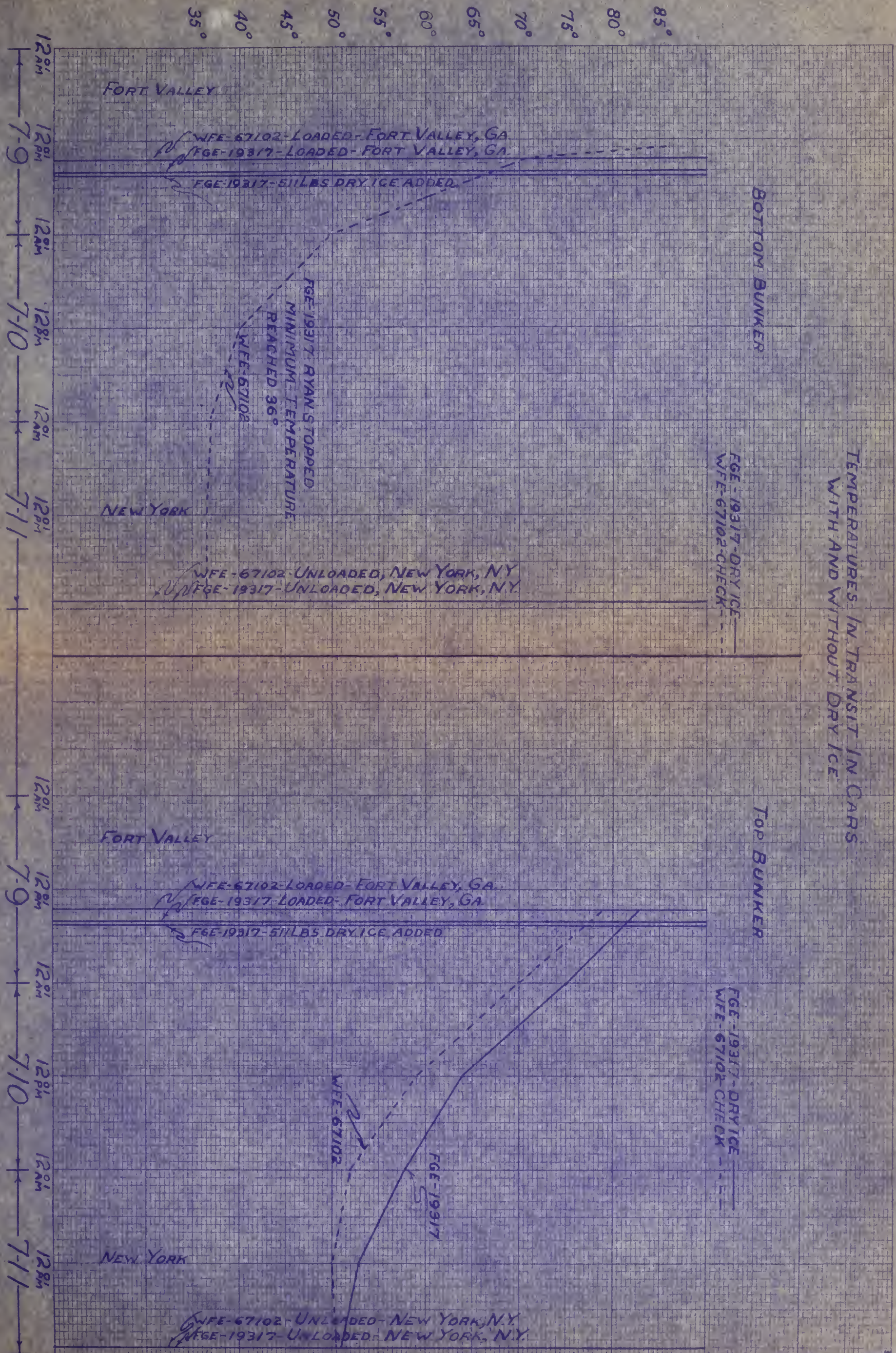




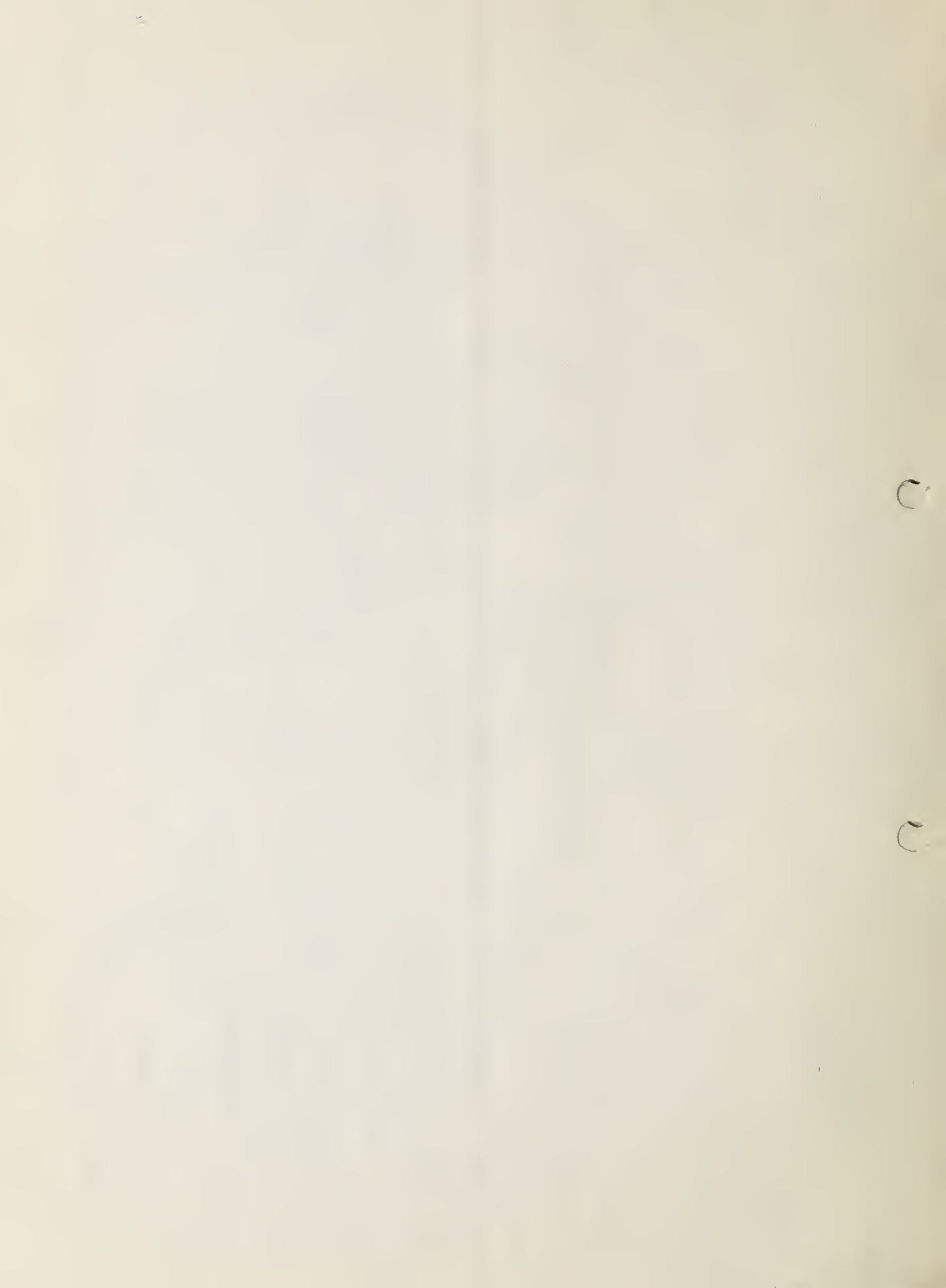












COMPARISON OF SHIPMENT OF PEACHES BY RAIL UNDER  
ORDINARY REFRIGERATION AND ORDINARY  
REFRIGERATION PLUS 700 POUNDS  
OF DRY ICE

From Marshallville, Ga., to New York, N. Y.,  
July 17 to 20, 1940.

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This test with Elberta peaches was started July 17, 1940. Permission to use cars WFE 60099 and WFE 66268 was obtained after they were loaded, which was before noon on the day of shipment. On this account, in order to provide suitable test lots, it was necessary to transfer 4 half-bushel test baskets from each car to the other. Thus in the final arrangement each car had 2 test baskets at the bottom-center and 6 at the top center. The test lots were evenly divided as to the cars from which they originally came. A Ryan thermograph was used in each position. WFE 66268 was finally closed at 4:00 p.m. and WFE 60099 at 5:30 p.m.

The peaches showed a pressure test ranging from 6.5 to 14.0 pounds, averaging 10.5 pounds. The temperature of the fruit in the shed was 86° to 88° F.

At 5:30 p.m. 700 pounds of dry ice costing \$21 was added to the bunkers of WFE 60099. At 6:00 p.m. it had 15.5 percent of CO<sub>2</sub>; at 6:35 p.m., 18.0 percent; and at 8:45 p.m., 16.3 percent. At 8:45 p.m. a bunker was opened at each end of the car and 2 cakes of dry ice in each were broken into several pieces, because the large amount of frost on the cakes seemed to be checking sublimation.

An analysis at 9:50 p.m. showed 17.7 percent of CO<sub>2</sub> and one at 11:30 p.m. showed 16.8 percent of CO<sub>2</sub>.

Both cars were from Chase & Company Cooperative at Marshallville. WFE 60099 was consigned to Chase & Company Cooperative, New York, N. Y., and WFE 66268 to Sawyer & Company, Newark, N. J.

About 800 half bushels were loaded into each car. WFE 60099 was unloaded about 11:00 p.m., July 19, and the test baskets were removed to the New York laboratory and first inspected July 20. The test fruit was removed from WFE 66268 about 44 hours later than from the dry-ice car, so that the first inspection could not be made until July 22.

The check fruit at first- and second-day inspections was about as ripe as the treated fruit at the second- and third-day inspections. The following decay record was obtained:

Record of Brown Rot After Unloading

	<u>First day</u>		<u>Second day</u>		<u>Third day</u>		<u>Fourth day</u>	
	<u>Top</u>	<u>Bot.</u>	<u>Top</u>	<u>Bot.</u>	<u>Top</u>	<u>Bot.</u>	<u>Top</u>	<u>Bot.</u>
	<u>Percent</u>		<u>Percent</u>		<u>Percent</u>		<u>Percent</u>	
Dry-ice car	0.5	0.4	2.1	1.5	7.5	7.0	15.6	20.6
Check-----	2.2	1.9	8.5	3.5	17.3	7.9	31.4	16.9

Inspections on the first day after removal from the car showed 4 times as much brown rot in the check as in the dry-ice car. During the 4 days' holding period the fruit that had been at the top doorway in the check car developed twice as much brown rot as that from a similar position in the dry-ice car. Decay in



fruit from the bottom doorway was practically the same in the 2 cars. During the first 4 days after unloading the decay in the fruit from the top of the dry-ice car was approximately the same as in the fruit from the bottom of the check car, although the latter had been about 10° colder during transit. Counting from the time of removal from the car in each case, the gas-treated fruit was about 36 hours behind the check fruit in developing a particular percentage of decay.





35° 40° 45° 50° 55° 60° 65° 70° 75° 80° 90° 95°

12<sup>01</sup>  
12<sup>01</sup>  
7-17  
12<sup>01</sup>  
12<sup>01</sup>  
7-18  
12<sup>01</sup>  
12<sup>01</sup>  
7-19  
12<sup>01</sup>  
12<sup>01</sup>  
7-19

MARSHALLVILLE, GA

WFE-66268-LOADED-MARSHALLVILLE, GA  
WFE-60099-LOADED-MARSHALLVILLE, GA

WFE-60099-700 LBS DRY ICE ADDED

TOP DOORWAY

TEMPERATURES IN TRANSIT IN CARS  
WITH AND WITHOUT DRY ICE

PIER 29, NY

WFE-60099-UNLOADED-PIER 29, N.Y.

WFE-66268-UNLOADED-AT 8:00 PM 7-21-40 NEWARK, N.J.

WFE-60099 DRY ICE  
WFE-66268 CHECK

MARSHALLVILLE, GA

WFE-66268-LOADED-MARSHALLVILLE, GA  
WFE-60099-LOADED-MARSHALLVILLE, GA

WFE-60099-700 LBS DRY ICE ADDED

BOTTOM DOORWAY

PIER 29, N.Y.

WFE-60099-UNLOADED-PIER 29, N.Y.

WFE-66268-UNLOADED-AT 8:00 PM 7-21-40 NEWARK, N.J.

WFE-60099 DRY ICE  
WFE-66268 CHECK





COMPARISON OF SHIPMENT OF PEACHES BY TRUCK UNDER ORDINARY  
REFRIGERATION AND ORDINARY REFRIGERATION  
SUPPLEMENTED WITH 450 POUNDS OF DRY ICE

From Zenith, Ga., to Washington, D. C., and New York,  
N. Y., July 18 to 21 1940.

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This test with Elberta peaches was started from Zenith, Ga., July 18, 1940. The peaches were of the 1 3/4- to 2-inch size and were packed in bushel baskets. Their pressure test ranged from 6.5 to 16.0 pounds and averaged 11.5 pounds. The peach temperatures at time of loading averaged 80.2° F.

The baskets were loaded 5 wide and 6 high. Test baskets were placed at top and bottom, front and rear, with a Ryan thermograph in the center of each basket. The dry-ice truck had 376 bushels and the check truck 400 bushels. The air duct in the dry-ice truck was only 2 feet long, whereas that in the check truck ran all the way to the rear. Neither truck had ice in the bunker until after the loading was finished, but the fans were running during loading. The dry-ice truck was closed at 2:45 p.m. and the check truck at 8:00 p.m.

At 4:15 p.m., 450 pounds of dry ice was placed on top of the water ice in the freshly filled bunker. The following gas records were obtained:

<u>Time</u>	<u>Percent</u>	<u>Time</u>	<u>Percent</u>
5:30 p.m.	43.0	9:20 p.m.	31.0
6:30 p.m.	40.2	10:40 p.m.	21.6
7:30 p.m.	35.2	12:00 p.m.	15.9
8:15 p.m.	33.0	12:50 a.m.	10.2



After the blower had been running 3 hours with the dry ice in the bunker it was found that there were two 1-inch drains wide open in the main body of the truck. These were then closed. When the dry-ice truck was reiced at 12:50 a.m. it was found that practically all the water ice was gone, which may have favored the rapid disappearance of the dry ice. The check truck was an hour or so ahead of the dry ice truck so that there was no opportunity to compare the ice meltage in the two trucks.

The dry-ice truck was diverted to N. J. Ward, Washington, D. C. and was unloaded there about 6:00 a.m., July 20. The check truck went to Yeckes Eichenbaum in New York, N. Y. It arrived late on July 20 and was held in a parking lot till 8:00 p.m., July 21, when 100 baskets were removed. It was then closed, and it was not possible to secure the test baskets until nearly midnight.

The following pressure tests were obtained:

	DRY-ICE TRUCK		CHECK TRUCK	
	First day	Third day	First day	Second day
	Pounds	Pounds	Pounds	Pounds
Top bunker----	12.5	4.5	5.5	Too soft for test.
Bottom bunker--	12.4	2.8	5.2	
Top rear-----	11.3	3.4	9.0	
Bottom rear---	12.5	4.6	5.4	
Average-----	12.2	3.8	6.3	

There was a marked contrast between the fruit in the 2 trucks. The peaches from the check truck were too soft for pressure tests on the second day, whereas the fruit from the dry-ice truck was still firm enough to test on the third day. A variation in pressure tes<sup>t</sup>

in the different parts of the same load was noted, particularly in the check truck, whereas in the dry-ice truck the variation was insignificant. The record for the check truck suggests that the overhead duct was giving the top rear more than its share of refrigeration. A comparison of the temperature charts for the 2 trucks shows that the truck with the overhead duct was cooler in the rear than the other, but warmer at the bunker. In both trucks the fruit in the top was cooler than that in the bottom.

In attempting to compare the fruit from the 2 trucks it is impossible to judge how much allowance should be made for the fact that the peaches from the check were unloaded 42 hours later than those from the dry-ice truck. The Ryan records, however, show that during the delay the temperature in the bottom of the check load did not go above 50° F., and that the temperature in the top of the load was in the low 40's. Holding for 42 hours at such temperatures could not account for the extreme contrast in firmness between this fruit and that in the dry-ice truck.

The following record on decay was obtained:

# Record of Decay After Unloading

## Dry-ice truck.

	First day		Third day		Fourth day	
	Rhizopus rot	Brown rot	Rhizopus rot	Brown rot	Rhizopus rot	Brown rot
	Percent	Percent	Percent	Percent	Percent	Percent
Top bunker----	0	0	0	0	0	0
Bottom bunker--	0	0	0	0	0	1.1
Top rear-----	0.4	0	0.4	0	1.5	1.6
Bottom rear---	0	0	0.5	0.5	0.5	1.1

Check truck.

	First day		Second day		Third day		Fourth day	
	Rhiz- opus rot	Brown rot	Rhiz- opus rot	Brown rot	Rhiz- opus rot	Brown rot	Rhiz- opus rot	Brown rot
	Percent		Percent		Percent		Percent	
Top bunker---	0	0	0	3.1	0	4.6	0	10.9
Bottom bunker	0	0	1.8	2.2	1.8	6.5	1.8	8.9
Top rear-----	0	0	0	1.9	2.0	6.3	2.0	14.2
Bottom rear--	0	0.4	0	3.6	0	4.6	0	15.3

There was more than twice as much decay in the fruit from the check truck on the second day as in that from the dry-ice truck on the fourth day. The total decay at the end of the third day of holding was 18 times as great in the fruit from the check truck as in that from the dry-ice truck. The delay of 42 hours at temperatures of 40° to 50° F. can account for but a small part of this difference.

With decay as with pressure tests it is interesting to note the small differences found between fruit from the different parts of the load in the dry-ice truck.

The fruit unloaded in Washington was held at 70° F., whereas that unloaded in New York was held at 80° or higher. This difference in temperature would have a decided effect upon the rate of softening, especially after the first day, but it should not have much effect upon brown rot.



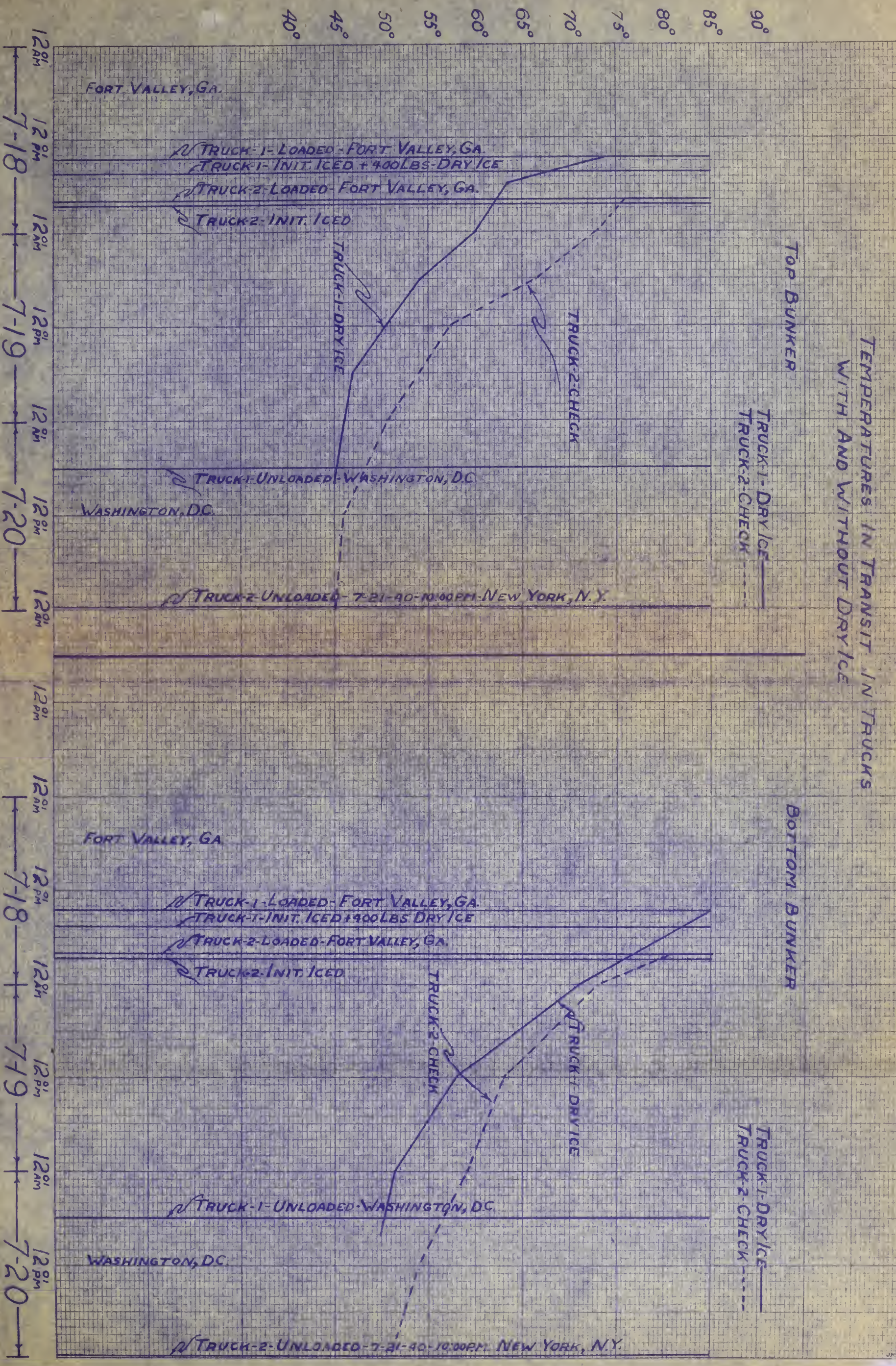
# TEMPERATURES IN TRANSIT IN TRUCKS WITH AND WITHOUT DRY ICE

TOP BUNKER

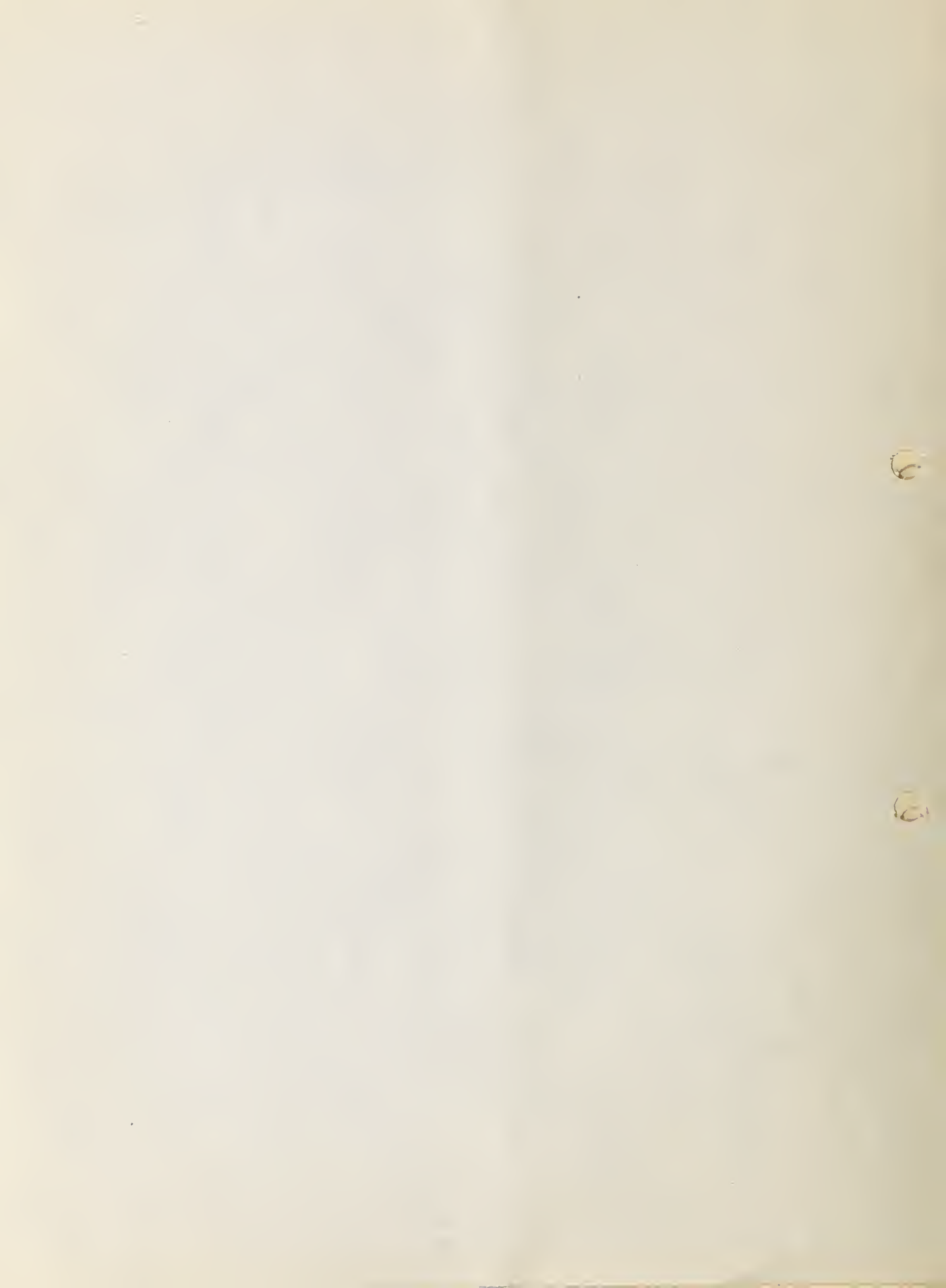
TRUCK 1 - DRY ICE  
TRUCK 2 - CHECK

BOTTOM BUNKER

TRUCK 1 - DRY ICE  
TRUCK 2 - CHECK



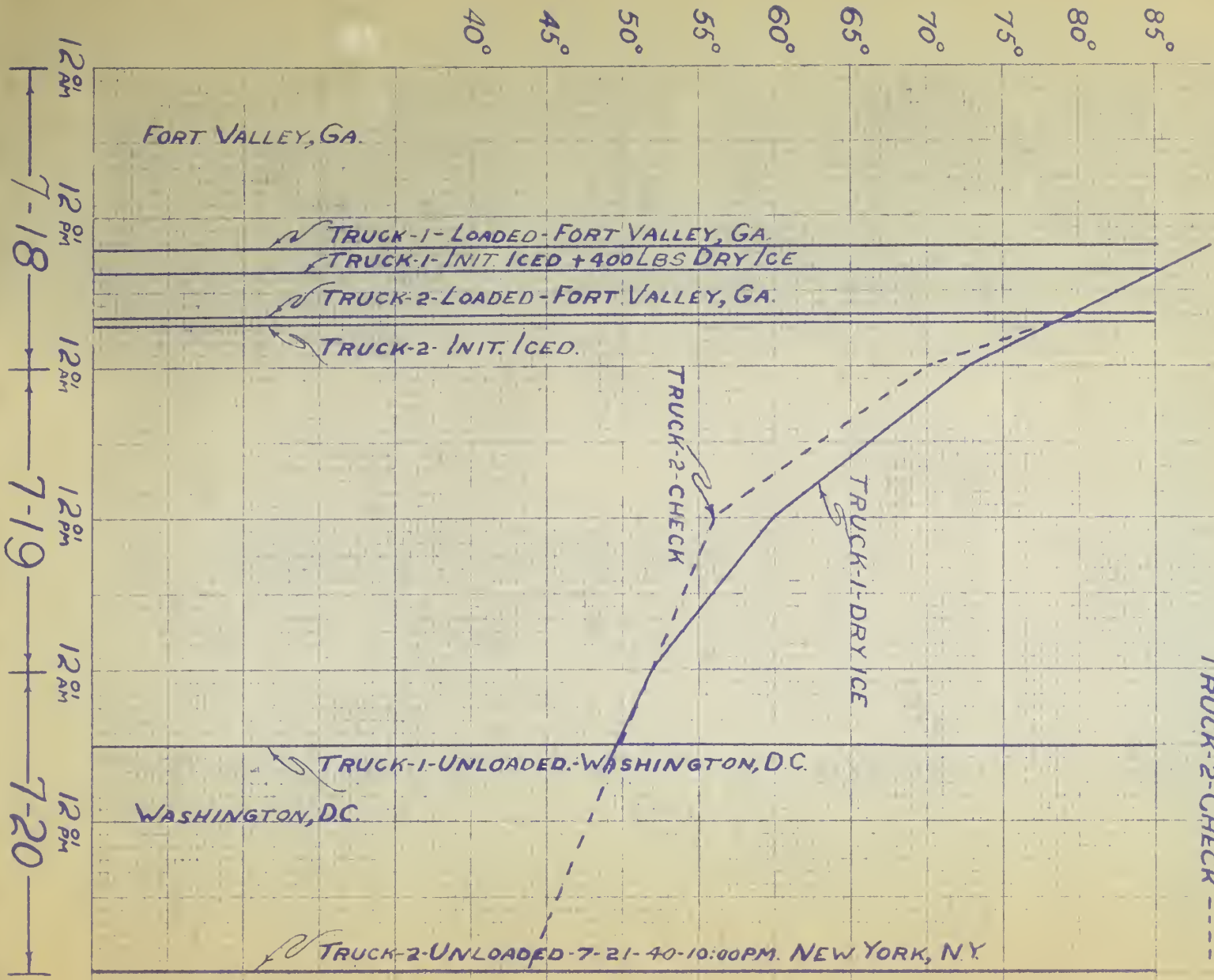




# TEMPERATURES IN TRANSIT IN TRUCKS WITH AND WITHOUT DRY ICE

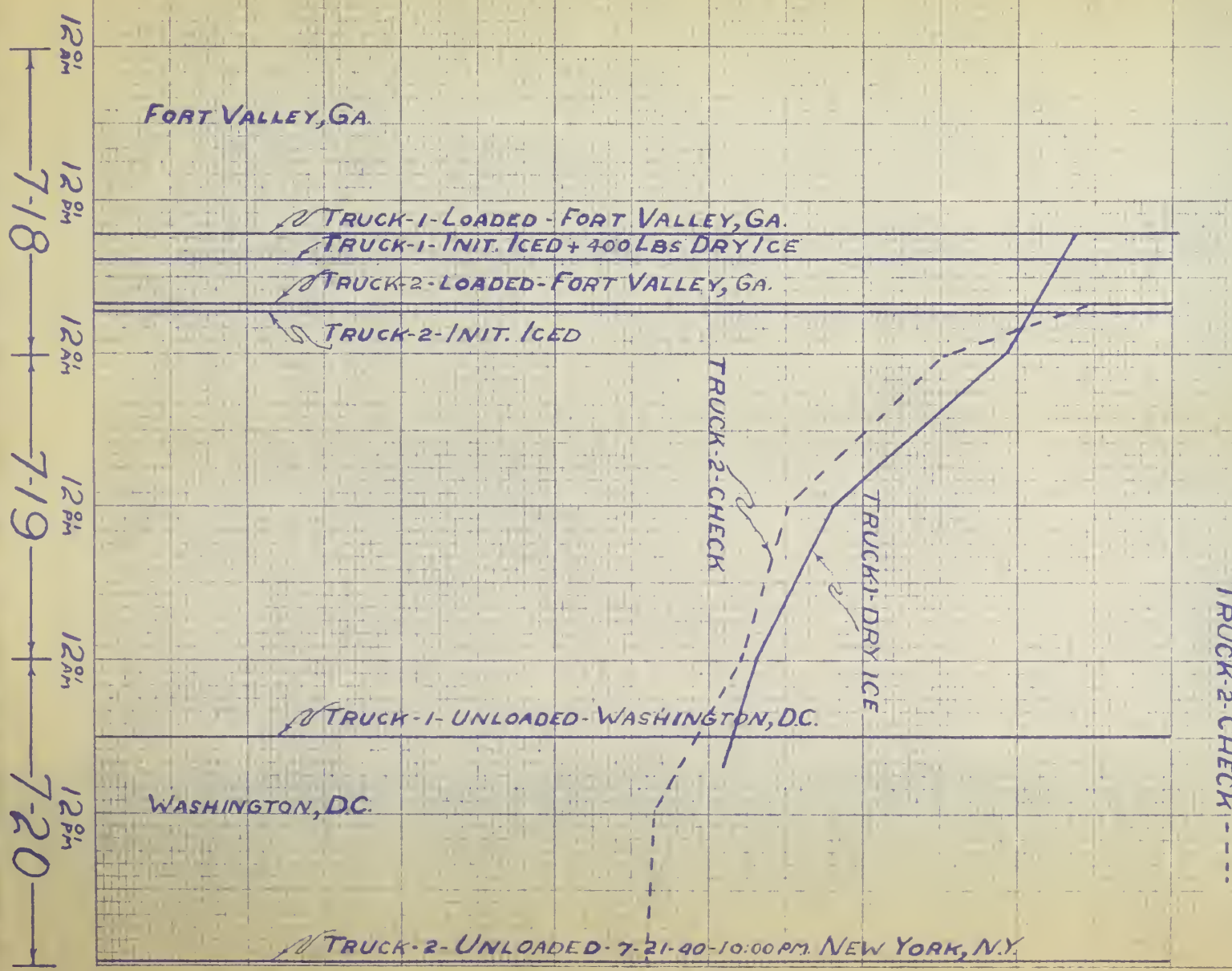
TOP REAR

TRUCK-1-DRY ICE —  
TRUCK-2-CHECK - - - -



BOTTOM REAR

TRUCK-1-DRY ICE —  
TRUCK-2-CHECK - - - -







COMPARISON OF SHIPMENT OF PEACHES UNDER ORDINARY  
REFRIGERATION AND UNDER VENTILATION

From Ft. Valley, Ga., to New York, N. Y.,  
July 19-22, 1940.

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The two trucks in this test were loaded with Elberta peaches at the John Pearson packing house, Ft. Valley, Ga., July 19, 1940. The test peaches were of the "2-inch and up" size, as were most of the loads in each truck although a few baskets of 1 3/4 to 2 inches were included. The test peaches showed a pressure test ranging from 5 to 13.5 pounds and averaging 9.4 pounds. The fruit temperatures at time of loading ranged from 82° to 84° F.

The peaches were packed in bushel baskets and the baskets were loaded 5 wide and 6 high. Each truck had 400 bushels. One test basket was placed at the bottom center and 2 test baskets at the top center of each load. A Ryan thermograph was placed in the center of a basket at each position.

Both trucks were constructed for refrigeration and both had overhead air ducts, but in this test one truck went under ventilation and the other was refrigerated, the ice being added after the loading was completed. The fruit in both trucks was owned by Roy Van de Grift, a large truck-owner, and was consigned to J. Nagler, 631 Washington Street, New York, N. Y.

The ventilated truck was unloaded at about 12:15 a.m., July 22, and the refrigerated truck at 5:30 a.m. on the same day.

The following record was obtained on decay:

Record of Decay After Unloading

	First day		Second day		Third day		Fourth day	
	Rhiz- opus rot	Brown rot	Rhiz- opus rot	Brown rot	Rhiz- opus rot	Brown rot	Rhiz- opus rot	Brown rot
	Percent		Percent		Percent		Percent	
Ventilated truck								
Top center---	1.9	14.2	1.9	25.2	1.9	31.5	2.5	41.5
Bottom center	1.0	4.7	1.0	9.2	1.0	15.3	2.7	20.4
Refrigerated truck								
Top center---	0	0	0	1.8	0	5.7	0	12.9
Bottom center	0	0.5	0	4.0	0	9.9	0	20.4

At the first inspection the fruit from the ventilated truck had more than 40 times as much decay as that from the refrigerated truck; about 11 percent in the ventilated truck and 0.25 percent in the refrigerated truck. At the inspection on the second day about three times as much additional decay had developed on fruit from the ventilated truck as on that from the refrigerated truck. No Rhizopus was found in the refrigerated truck and only a total of 2.6 percent was found in the ventilated truck at the end of the fourth day.



The following pressure tests were obtained:

	VENTILATED TRUCK		REFRIGERATED TRUCK	
	<u>First day</u>	<u>Second day</u>	<u>First day</u>	<u>Second day</u>
	Lbs.	Lbs.	Lbs.	Lbs.
Top center-----	4.6	Too ripe	9.7	3.5
Bottom center-----	4.7	for	8.8	3.3
		test		

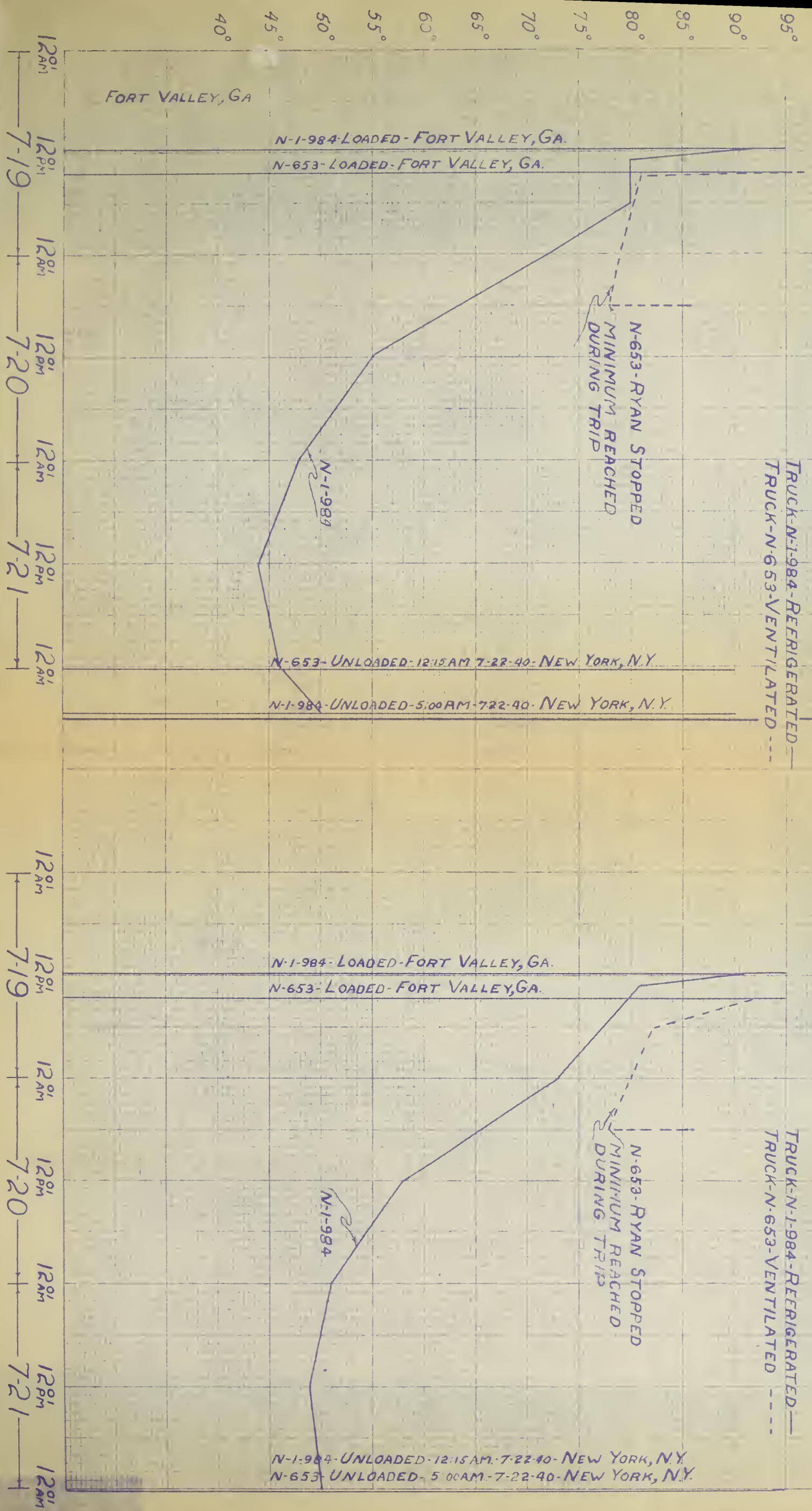
The ventilated fruit carried remarkably well considering the high temperatures that prevailed at the time. The cost of transportation under ventilation was 50 cents per bushel as compared with 60 cents per bushel with refrigeration. However, from observation of the condition of the peaches from the two trucks it seemed evident that the difference in quality of the fruit was not adequately represented by the difference of 10 cents per bushel in the transportation costs. The refrigeration undoubtedly added more than 10 cents a bushel to the market value of the fruit, but no record of market returns was obtained.



TEMPERATURES IN TRANSIT IN TRUCKS  
WITH AND WITHOUT ICE

TOP CENTER

BOTTOM CENTER







COMPARISON OF SHIPMENT OF PEACHES BY RAIL UNDER ORDINARY  
REFRIGERATION AND UNDER SIMILAR REFRIGERATION PLUS  
(a) 550 POUNDS DRY ICE PLACED ON TOP OF THE LOAD AND  
250 POUNDS ON THE WATER ICE IN THE BUNKERS. AND (b)  
800 POUNDS DRY ICE PLACED ON TOP OF THE WATER ICE IN  
THE BUNKERS

From Woodland, Ga., to New York, N. Y., July 24-28,  
1940

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The check car, FDE 9058, was loaded with Elberta peaches at the packing house of C. W. Mathews on a local switch. The fruit for the two dry-ice cars, FGE 51146 and FDE 9140, was likewise of the Elberta variety and was packed at the shed of B. A. Dunn, Manchester, Ga., and hauled to a switch near the Woodland railroad station. All of the test fruit was from the Dunn packing house.

The peaches were of the "2-inch and up" size and many of them were 3 inches or larger. They gave a pressure test ranging from 10.0 to 15.0 pounds but averaged 11.84 pounds. The average fruit temperature at time of loading was 87.5° F.

The two FDE cars were of the double-deck type and of very tight construction. The FGE car was in good average condition but did not retain CO<sub>2</sub> gas satisfactorily.

The peaches were packed in bushel baskets loaded 5 wide and 3 high. Test lots of one bushel each were placed at the top and bottom bunker and top and bottom doorway positions. Ryan thermographs were placed in the centers of the baskets at bottom bunker and top doorway positions.

Loading was finished in FDE 9140 and FGE 51146 at 2:30 p.m. and in FDE 9058 at 3:30 p.m.

At 4:15 p.m. 800 pounds of dry ice costing \$24 was placed in FGE 51146. Two hundred and fifty pounds of this was divided between the bunkers and 550 pounds placed in 10 baskets supported on the load near the doorway. One 50-pound cake was broken into pieces. The baskets were held in place by a wire stretched across the car and running through the handles of the baskets. Two lid pads had been placed in the bottom of each basket and the wrapping paper on the dry ice was pushed down on the sides of the blocks without being removed from the under side. At 5:10 p.m. 800 pounds of dry ice costing \$24 was divided between the bunkers of car FDE 9140.

All of the cars had 9600 pounds of ice in the bunkers when sent out for loading. All three cars received salt equal to 5 percent of the ice supplied at the first reicing, but thereafter the salt added was only 3 percent of the ice supplied. The reicing record

for ice and salt is as follows:

Station	Date	Time	FGE 51146		FDE 9140		FDE 9058	
			Ice lbs.	Salt lbs.	Ice lbs.	Salt lbs.	Ice lbs.	Salt lbs.
Manchester	7/24/40	11:29 p.m.	5700	288	5300	288	6300	288
Atlanta	7/25/40	6:22 a.m.	3100	93	2500	75	2600	78
Spencer	7/25/40	8:29 p.m.	2000	60	1700	51	2000	60
Potomac Yards	7/26/40	9:45 p.m.	1400	42	1100	33	1300	39
Jersey City	7/28/40	3:00 p.m.	4100	--	4100	--	----	--
" "	7/27/40	5:15 p.m.	----	--	----	--	2600	--

No record was taken of the quantity of ice in the bunkers at the time of unloading.



The following carbon dioxide record was obtained:

FGE 51146		FDE 9140	
<u>Time</u>	<u>Percent</u>	<u>Time</u>	<u>Percent</u>
5:15 p.m.	20.0	6:15 p.m.	28.0
6:20 p.m.	21.8	7:10 p.m.	35.6
7:15 p.m.	22.6	9:10 p.m.	40.6
9:15 p.m.	20.8	12:20 a.m.	39.4
12:15 a.m.	19.6	7:10 a.m.	21.0
7:15 a.m.	10.4		

The greater tightness of FDE 9140 is very evident in the fact that the concentration of gas maintained was approximately twice as great as in car FGE 51146.

The three cars were pulled out of Woodland about 11:30 p.m. and reiced at Manchester shortly after midnight. All three cars were unloaded in New York between 9:00 and 12:00 p.m., July 28.

The first inspection was made the morning of July 29. When FGE 51146 was opened there was still 30 to 35 pounds of dry ice in the baskets, as much as 5 pounds to the basket in some cases. The pads, damp from the moisture condensed on the solid CO<sub>2</sub>, had frozen stiff and in three cases this freezing had gone down into the basket of peaches beneath, and one or two fruits in the top layer were frozen fast to the pad. After warming, no injury was apparent.

In FDE 9140 there were three peaches in the basket at the bottom bunker that had watersoaked areas resembling freezing and probably resulting from that cause. In view of this it is hardly open to question that when dry ice is used in the bunker there should not be heavy additions of salt en route.

Upon arrival the fruit at the top doorway of the dry ice cars was colder and that at the bottom bunker approximately the same as that in the check car. The Ryan records showed that at noon the first day en route the temperature at the top doorway of the check car was 69° F., that of the car with dry ice overhead was 62°, and that of the car with dry ice in the bunker was 60°.

The following pressure test record was obtained after arrival:

	Dry ice overhead		Dry ice in bunkers		Check car	
	First day	Second day	First day	Second day	First day	Second day
Fruit from:	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Top doorway-	12.6	4.7	10.5	3.3	7.4	2.4
Top bunker--	12.9	5.4	12.0	4.1	9.3	2.3
Bottom door-						
way-----	12.5	4.6	12.2	5.4	11.3	3.1
Bottom bunker	12.5	8.2	13.7	9.8	12.3	6.1

On the first day after arrival the peaches from the top doorway of the overhead dry-ice car were firmer, as shown by pressure test, than those from the bottom-bunker position in the check car. On the second day after arrival the peaches from the top positions in the car with dry ice on top of the load showed more than twice as great firmness as those from the top layer of the check car. The fruit from the car with dry ice in the bunkers was also distinctly firmer than that from the check car, but the peaches from the top of the car did not make as good a showing as where the dry ice was placed over the load.

The following record on decay was obtained after holding the fruit for 3 days:

Record of Decay on Third Day After Unloading.

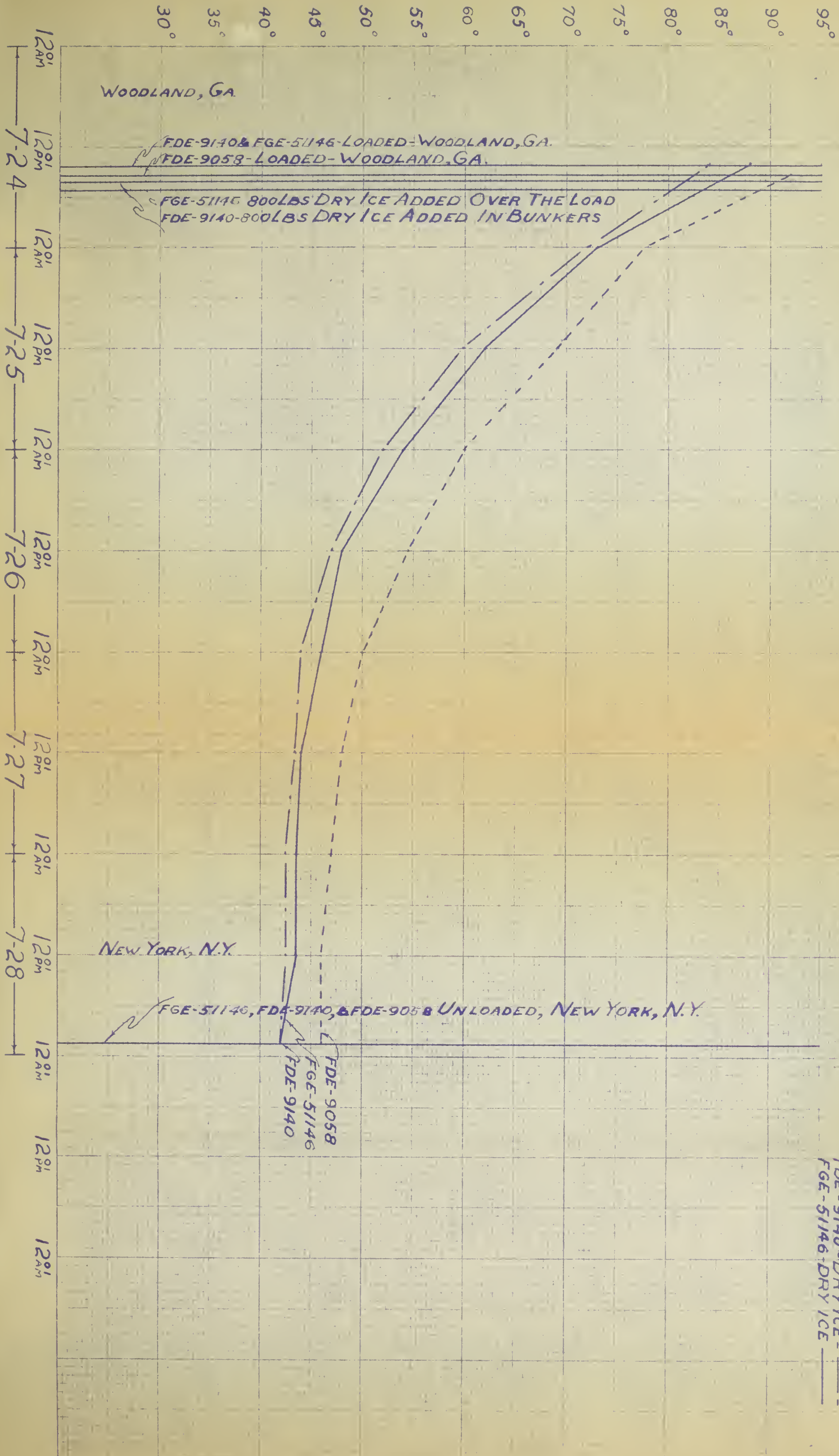
	<u>Dry ice overhead</u> Percent	<u>Dry ice in bunker</u> Percent	<u>Cheek car</u> Percent
Rhizopus rot:			
Top doorway-----	0	0.8	0
Top bunker-----	0	0	0
Bottom doorway----	0	0	1.0
Bottom bunker-----	0	0	0
Brown rot:			
Top doorway-----	2.1	10.1	4.5
Top bunker-----	2.6	2.7	1.5
Bottom doorway----	3.5	4.5	0
Bottom bunker-----	0.7	0	0

There was practically no decay in the fruit from any of the cars after 2 days' holding, and the above record made at the end of the third day shows too little spoilage to justify conclusions as to the effect of the different treatments.





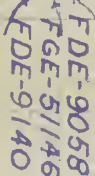
TEMPERATURES IN TRANSIT IN CARS  
WITH AND WITHOUT DRY ICE  
TOP DOORWAY







FDE-9058-CHECK---+--  
FDE-9140-DRY ICE-----  
FGE-51146-DRY ICE-----







COMPARISON OF SHIPMENT OF PEACHES UNDER ORDINARY REFRIGERATION  
AND UNDER ORDINARY REFRIGERATION PLUS (a) 800 POUNDS  
DRY ICE PLACED ON TOP OF LOAD, AND (b) 800 POUNDS  
DRY ICE PLACED ON TOP OF WATER ICE IN BUNKERS.

From Woodland, Ga., to New York, N. Y.,  
July 26-31, 1940.

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The shipping conditions in this test were almost identical with those reported in the test of July 24. The check car was loaded with Elberta peaches at the Mathews shed and the two dry-ice cars with Elbertas from the Dunn shed. The test lots of peaches were Elbertas purchased from Dunn, as before.

The peaches were of the "2-inch and up" size and were packed in bushel baskets. They gave a pressure test ranging from 7.5 to 12.5 pounds and averaged 10.99 pounds. The temperature of the fruit at time of loading ranged from 83° to 91° and averaged 89° F. The outdoor temperature ranged as high as 95°.

Loading was completed in FGE 33169 at 4:45 p.m., in FGE 14819 at 5:30 p.m., and in WFE 63661 at 6:15 p.m. The latter was used as the check. A test bushel basket with a thermograph in the center was placed at top doorway, bottom doorway, top bunker, and bottom bunker of each car. At 6:00 p.m. 800 pounds of dry ice was divided between the bunkers of FGE 33169. At 6:15 p.m. 800 pounds of dry ice was placed in 16 baskets resting on the top center of the load of FGE 14819 with pads and wires as in the earlier shipment. The paper, however, was entirely removed from the dry ice cakes. One

cake of dry ice was broken into pieces.

All of the cars had 9300 pounds of ice in the bunkers when sent out for loading. The later records of ice and salt are as follows:

<u>Station</u>	<u>Date</u>	<u>Time</u>	FGE 14819		FGE 33169		WFE 63661	
			<u>Ice</u>	<u>Salt</u>	<u>Ice</u>	<u>Salt</u>	<u>Ice</u>	<u>Salt</u>
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Manchester----	7/26/40	9:50 p.m.	6700	288	5200	288	6200	288
Atlanta-----	7/27/40	6:00 a.m.	2600	78	3000	90	2800	84
Florence-----	7/27/40	7:05 p.m.	2300	69	2700	81	2000	60
Potomac Yards-	7/28/40	11:02 a.m.	1900	57	2100	63	2000	60

The following CO<sub>2</sub> record was obtained:

<u>FGE 33169</u>		<u>FGE 14819</u>	
	<u>Percent</u>		<u>Percent</u>
7:00 p.m.	18.2	7:15 p.m.	13.6
9:00 p.m.	23.0	9:10 p.m.	15.6
10:35 p.m.	23.8	10:45 p.m.	16.6
6:30 a.m.	8.2	6:40 a.m.	9.5

It was thought before loading that FGE 14819 was a slightly tighter car than FGE 33169, but it was later discovered that water was leaking through its floor under the bunkers, and the drains were so loose they could be readily shaken around in the floor. Heavy gas leakage from this car is evident in the low CO<sub>2</sub> records obtained.

The cars reached Jersey City on the morning of July 29, but the consignee had an oversupply of peaches so that the cars were held in Jersey City without opening. FGE 33169 and FGE 14819 were not opened for unloading until 10:00 p.m. July 30, and WFE 63661 was

held until 9:00 p.m., July 31, making fifth- and sixth-day unloading instead of the usual third-morning.

When FGE 14819 was opened there was about 25 pounds of dry ice left in the baskets over the load, a small quantity in nearly every basket. No evidence of freezing was found in any of the cars.

The following pressure test record was obtained after unloading:

Position	Dry ice over load		Dry ice in bunker		Check car	
	First day	Second day	First day	Second day	First day	Second day
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Top doorway----	13.5	3.5	10.7	3.6	9.9	2.5
Top bunker-----	12.2	3.8	10.0	2.3	9.6	2.4
Bottom doorway--	13.6	3.1	12.3	4.4	12.8	3.1
Bottom bunker--	13.6	7.2	13.6	7.4	13.4	7.7

On the first day after unloading the peaches from the top doorway of the car with dry ice on top of the load were as firm, as shown by pressure test, as those from the bottom bunker of the check car. They gave a pressure test of 3.6 pounds higher than those from the top doorway of the check car and 2.8 pounds higher than those from the top doorway of the car with dry ice in the bunker. On the second day the pressure tests of the top-doorway fruit of the dry-ice cars were still 40 percent higher than those of the check car. The record for the top bunker fruit from the car with dry ice over the load was similarly favorable as compared with that from the same position in the control car.



During 5 days' inspection there was only one Rhizopus rot and that was in the basket from the top doorway of the check car on the first day.

The following record was obtained on brown rot:

Record of Decay After Unloading

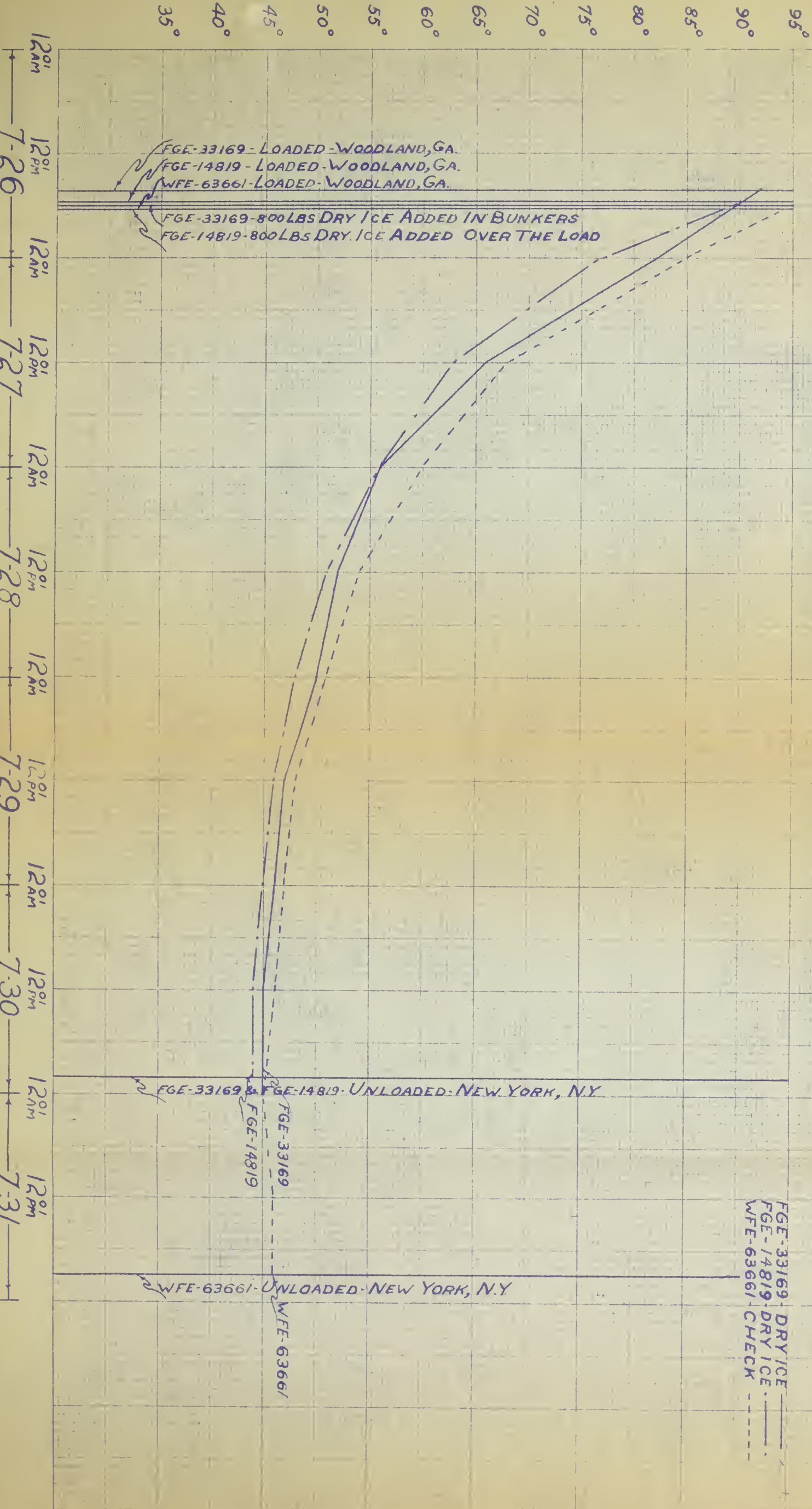
	Dry ice on top of load		Dry ice in bunkers		Check car	
	After second day	After fifth day	After second day	After fifth day	After second day	After fifth day
	Percent	Percent	Percent	Percent	Percent	Percent
Top doorway	0.6	2.6	2.3	9.5	3.9	6.2
Top bunker	1.3	7.5	1.3	6.2	0.8	2.3
Bottom doorway	0.0	3.2	1.9	8.1	0.8	6.5
Bottom bunker	0.7	0.7	0.0	1.1	0.0	6.1

Not much rot developed and its occurrence was not greatly modified by treatment or by location in the car. After 2 days' holding there was six times as much decay in the fruit from the top doorway of the check car as in the fruit from the same position in the car with dry ice on top of the load. The average decay for the four positions in the check car was twice as great as for the car with dry ice over the load. The decay in the car with dry ice in the bunkers was approximately the same as that in the check car.

Both the record on firmness and the record on decay indicate that dry ice placed over the load has much greater value than dry ice placed in the bunker in protecting the parts of the load in greatest need of protection and in insuring the safe arrival of all of the fruit. However, records were not obtained which would indicate whether or not the \$24 cost of the dry ice was recovered in a higher return on the fruit from the cars that received the gas treatment.

# TEMPERATURES IN TRANSIT IN CARS WITH AND WITHOUT DRY ICE

TOP DOORWAY







TEMPERATURES IN TRANSIT IN CARS  
WITH AND WITHOUT DRY ICE

BOTTOM DOORWAY

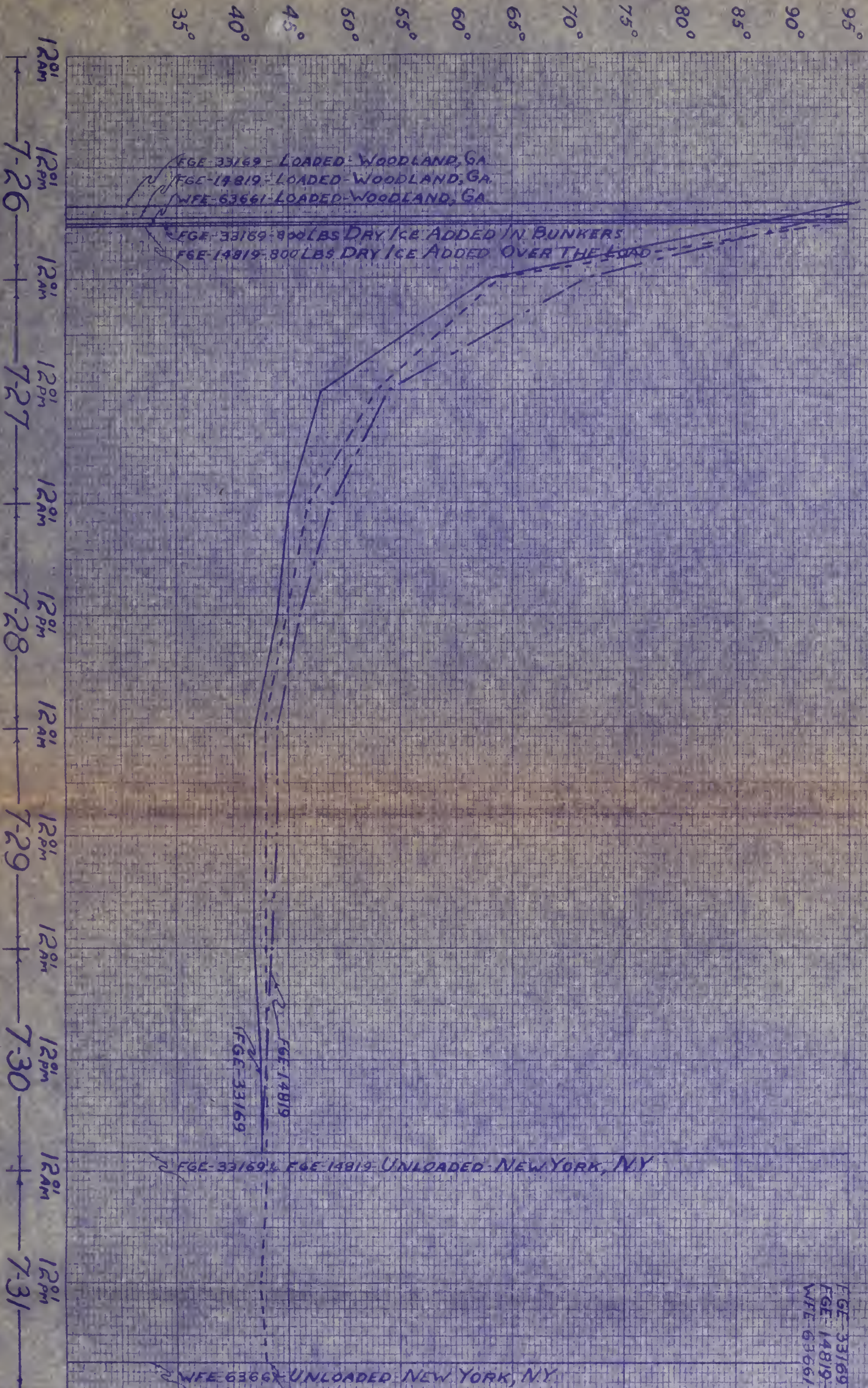
FGE-33169 - LOADED - WOODLAND, GA  
FGE-14819 - LOADED - WOODLAND, GA  
WFE-63661 - LOADED - WOODLAND, GA

FGE-33169 - 800 LBS DRY ICE ADDED IN BUNKERS  
FGE-14819 - 800 LBS DRY ICE ADDED OVER THE LOAD

FGE-33169, FGE-14819 UNLOADED - NEW YORK, NY

WFE-63661 UNLOADED - NEW YORK, NY

FGE-33169 - DRY ICE  
FGE-14819 - DRY ICE  
WFE-63661 - CHECK

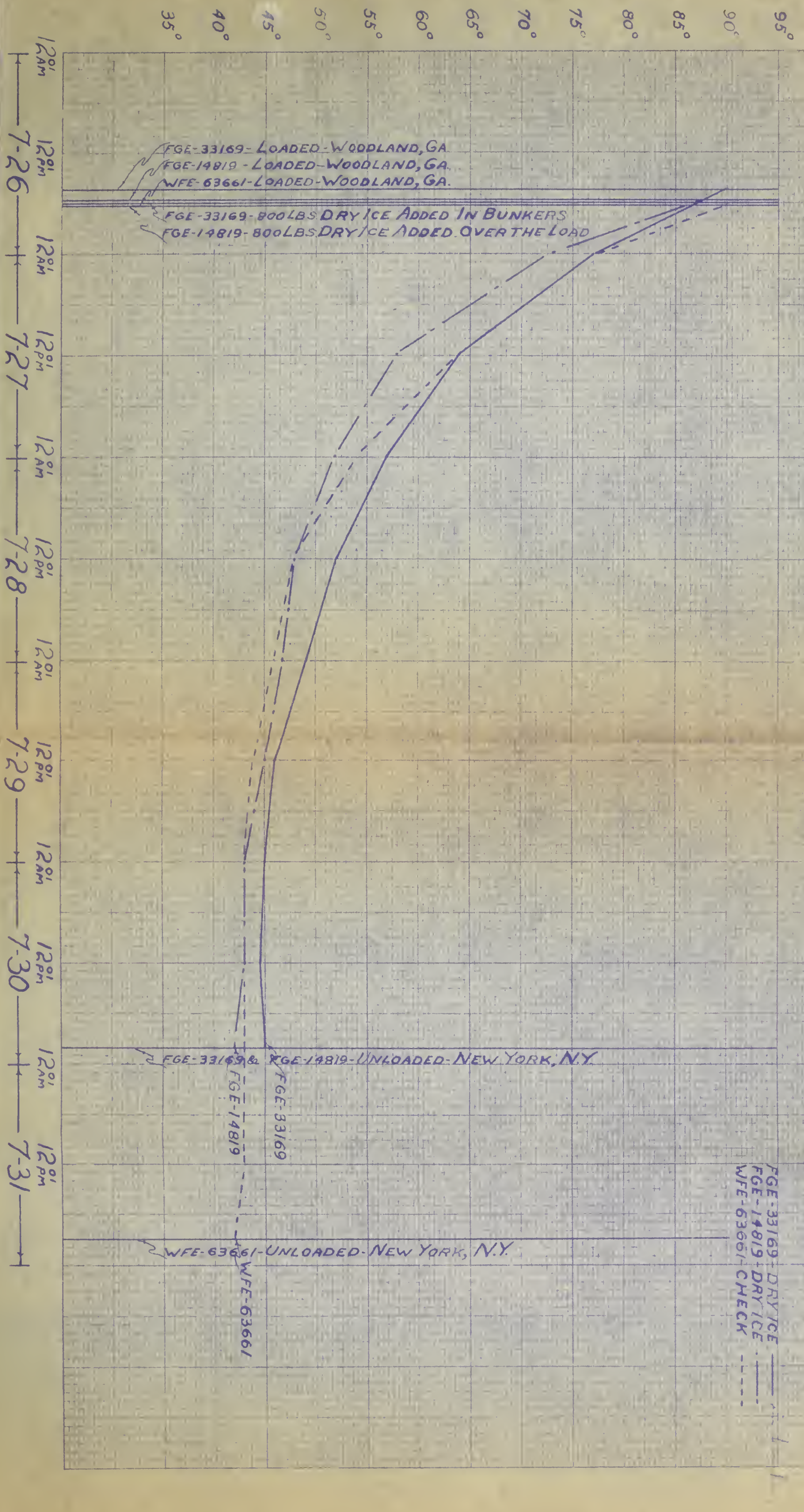






TEMPERATURES IN TRANSIT IN CARS  
WITH AND WITHOUT DRY ICE

TOP BUNKER







# TEMPERATURES IN TRANSIT IN CARS WITH AND WITHOUT DRY ICE

BOTTOM BUNKER

